COLUMBIA RIVER TREATY

HYDROMETEOROLOGICAL COMMITTEE

2011

ANNUAL

REPORT

Snow Survey (BC Hydro)

Stephanie Smith (lead)	BC Hydro, Canada, Canadian Chair
Adam Gobena	BC Hydro, Canada, Member
Peter Brooks	U.S. Army Corps of Engineers, U.S., U.S. Co-Chair
Ann McManamon	Bonneville Power Administration, U.S., U.S. Co-Chair

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Introduction

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities. The Committee is responsible for planning and monitoring the operation of the hydrometeorological data collection network in accord with the Columbia River Treaty (CRT). It also assists the Entities in matters related to hydrometeorological and water supply forecasting.

This report summarizes Committee activities during the 2011 water year (October 1, 2010 – September 30, 2011). The Annual Report focuses on:

- action taken on proposed changes to the hydrometeorological monitoring network
- updates to CRT communications and data storage systems
- updates to data exchange requirements
- updates to forecasting procedures
- review of the 2011 CRT water supply forecasts
- other activities of the Committee

The Committee began issuing regular Annual Reports in 2001. General background information on Committee activities contained in the 2001 and 2002

annual reports is now presented in a separate supplemental document. The supplement contains general information that does not typically change from year to year. Appendices in the supplemental document include:

- Appendix A – Introduction to the Committee terms of reference
- Appendix B – Terms of reference for the CRTHC
- Appendix C – Process for reviewing hydrometeorological data networks
- Appendix D – List of contributors of hydrometeorological data
- Appendix E – Data communication and storage systems
- Appendix F – Data exchange reports
- Appendix G – Treaty studies, models, and forecast requirements

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See 2011 Supplemental Report for a list of Acronyms used in this report

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2011 Annual Summary

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities and is responsible for planning and monitoring the operation of hydrometeorological data collection network in accord with the Treaty and otherwise assisting the Entities as needed. The Committee consists of four members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Peter Brooks, USACE Co-Chair	Stephanie Smith, B.C. Hydro, Chair
Ann McManamon, BPA Co-Chair	Frank Weber, B.C. Hydro, Member
	Adam Gobena*, B.C. Hydro, Member

* There was one change in the Committee Membership in 2011. Adam Gobena replaced Frank Weber as Canadian Member of the Committee on September 26, 2011.

The CRTHC met three times in the 2011 operating year:

Meeting 66: November 30, 2010 at BC Hydro

Meeting 67: March 15, 2011 at BC Hydro

Meeting 68: August 30, 2011 at BPA

In addition, the CRTHC members participated in discussions with CRTOC members and others regarding the results of climate change studies conducted by both BC Hydro and the River Management Joint Operating Committee (RMJOC).

The 2010 CRTHC Annual Report was completed in January 2012, in advance of the annual Permanent Engineering Board Meeting.

Stations

The Committee process for reviewing proposed changes to the operation of stations within the hydrometeorological network is described in Appendix C of the 2011 Supplemental Report. The process is intended to ensure that changes made to the network do not negatively affect the monitoring, planning, and operations of Treaty facilities.

In 2010, the CRTHC wrote a station network status report documenting changes to the network from 2005-2010 which was presented to PEB in February 2011. There were no reported changes to the station network in 2011. CRTHC is working on an updated listing of all Treaty stations, and will be sending annual letters to agencies which manage Treaty monitoring stations to remind them of the importance of the continued operation of these stations. The Committee is continuing to address the question of adequacy of the network. The Committee plans to build on the station network status report during the coming year to better define which stations are critical to the operation of treaty projects and to develop a better process for monitoring those stations.

The Committee is developing a station hierarchy of importance to reflect those stations which were most critical to current Treaty operations and those which support that effort. As a preliminary start, the Committee agreed that stations used directly in regression-based water supply equations for the Treaty projects and those monitoring reservoir levels and key streamflow points would be classified as the highest tier. Stations used in daily operation or not used directly in forecast procedures would be classified at a lower tier. It is hoped that this tiered approach will permit better monitoring of those stations critical to the operation of the Treaty. As the work progresses, the Committee will determine the best way to report on the ongoing availability of these stations to the Operating Committee and Permanent Engineering Board.

SNOW PILLOW PROJECT

One deficiency in the station network that has been identified is a lack of real-time and late season snowpack data in the Canadian Columbia. BPA performed an analysis to determine best locations in the Canadian Columbia to convert existing snow courses to automated snow pillow sites to enhance the real-time monitoring of snow in the region. The resulting report developed an approach to identify which stations added the most additional information to the existing snow pillow network. The approach analyzed the first three (3) principal components of the analysis which explained over 80% of the variability of the snowpack. The approach pulled stations with the highest loadings from each of these principal components while also considering an adequate spatial and elevation distribution. Based upon available funding and gaps in the data network the effort proposed to add 5 additional automated stations mainly in the Mica / Revelstoke area. The final report was presented to the CRTOC in May. BPA and BCH are working out a Memorandum of Understanding regarding the

installation and maintenance of the sites. Field assessments of the proposed locations were undertaken in September 2011 with further assessments of alternate locations being done during the winter snow surveys of 2012. Installation of the new stations is planned to commence in the summer of 2012 and should be completed by October 2013.

Communication and data storage systems

The Columbia Basin Telecommunications (CBT), other communication systems, and the Columbia River Operational Hydromet System (CROHMS) are described in Appendix E of the 2011 Supplemental Report. The CBT system, operated by USACE in Portland, is the primary communications system for transmitting project data throughout the Columbia River. There are 30 nodes (projects) that comprise the CBT system Agencies, including the Northwest River Forecast Center (NWRFC), USACE, and BCH. CROHMS is the central system for collecting and re-distributing hydrometeorological data used to support the operations of Treaty projects, although the Entities also use other communication systems to exchange data.

BC Hydro converted to a new hydromet data management system called WISKI in July 2011. The USACE continues with testing of the new Regional Water Control Data System.

Data exchange

Appendix F of the 2011 Supplemental Report describes current data exchange procedures. Data exchanged among operational projects and entity agencies may be categorized according to the type of data and the frequency of transmission. Types of data include project data, weather and streamflow data, inflow forecasts, as well as reports and messages. The frequencies of transmission may be hourly, daily, or monthly.

During the changeover from Daylight Savings time to Standard time on November 7, 2010, the extra hour of generation at Mica over the time change caused an error in the h/k calculation for Treaty accounting. A permanent fix would be costly to implement into the existing data system at BC Hydro, so the solution applied is to try to limit generation changes over the transition hour, and to correct any issues after the fact.

Forecasting

LIBBY FORECAST PROCEDURE

The new Libby Forecast Procedure (LFP) using statistical equations developed in 2010 was implemented to forecast the April-August inflow to Libby Dam, Montana. The CRTOC accepted the 1- December – 1-July forecast equations on November 18, 2010 for use beginning in December 2010. Details of the new equations were presented in the 2010 CRTHC Annual Report.

DECISION SUPPORT MODEL FOR DECLARING THE ONSET OF THE KOOTENAY LAKE FRESHET

The annual declaration of the "commencement of the spring rise" on Kootenay Lake by the IJC International Kootenay Lake Board of Control (KLBC) has potential operational impacts on the management of Kootenay River system reservoirs as it can signal a relaxation in the operating restrictions. For this reason, the Columbia River Treaty Operating Committee (CRTOC) commissioned the CRT Hydrometeorological Committee (CRTHC) to undertake a study and provide the KLBC with an additional decision support tool for their annual deliberation of the declaration of the spring rise.

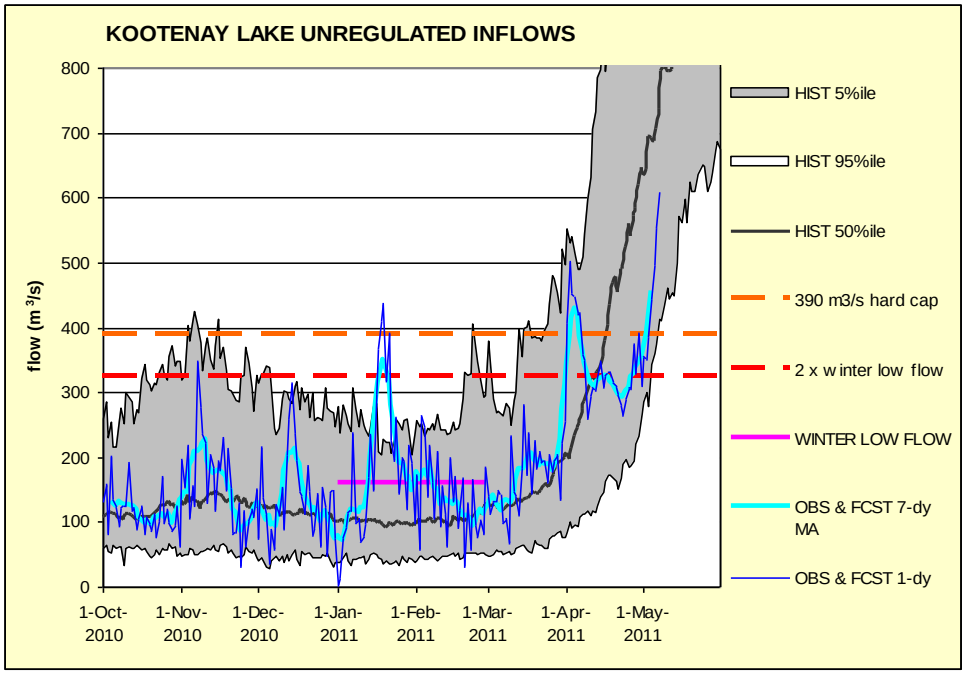
Frank Weber (BC Hydro) developed a model that uses as input observed and forecasted local Kootenay Lake inflows. Key characteristics of the model are its objectivity in declaring the freshet onset, flexibility to accommodate year-to-year variations in hydroclimatic conditions, robustness to day-to-day flow variability caused by poor data quality and natural hydrologic processes, and the use of a 4-day lead-time inflow forecast.

The procedure is not intended to replace human decision making, but provides guidance for declaring the start of the seasonal snowmelt freshet. It has been used unofficially in the water years since 2009 with success.

An updated version of the report and procedure were submitted to the KLBC in January 2011. The KLBC appreciated the input and will incorporate the additional decision support, along with other data and experience, to make its annual judgment on the declaration of the start of the spring rise.

In 2011, the spring rise was officially declared by the KLBC on May 3, 2011. This coincides well with the results from Kootenay Lake Freshet tool which indicated the spring rise started on May 4. There was a rise above the

threshold on April 4th, but it was recognized at the time that this was due to a heavy rain event in the preceding days, and that flows would probably recede back below the threshold as indeed did occur. See the figure below for a snapshot of the 2011 season.



REVISION TO NWS WATER SUPPLY FORECASTING TECHNIQUE

The Committee met with a representative of the Northwest River Forecast Center to discuss their intention to revise their method for generating water supply forecast from regression to ensemble analysis. The Ensemble Streamflow Prediction (ESP) technique has been used in the water resource community for many years for a variety of purposes. The Northwest River Forecast Center has been running ESP in parallel with their regression based water supply equations for several years and has determined that the forecasts generated by ESP are of equal or greater value.

Most of the forecasts used for operating the Treaty are still generated by the project owners. BC Hydro provides forecasts for Mica, Arrow and Duncan, while the USACE provides forecasts for Libby. These forecasts will continue to be generated monthly using the approved regression forecast procedures. However, for operating the entire system, forecasts are needed for a handful of other places, most notably The Dalles, which will be generated on a more frequent time scale than the regression procedures. The Committee recommended to the CRTOC that a single water supply forecast for each month be used for operating the Treaty. The date selected for each month was an attempt to provide the information as early as possible for computation of flood control while still allowing adequate time to incorporate monthly point snow observations. The date chosen is the 4th working day of each month. That schedule for 2012 is:

- January 6th
- February 6th
- March 6th
- April 5th
- May 4th
- June 4th
- July 3rd

The Hydrometeorological Committee with monitor the impact on operations of the forecasts released on these dates. Based upon those results, the Committee may revise its recommendation for future years.

Forecast Verification

The water supply forecasts and information on the hydrometeorology for the year are presented in the 2011 Annual Report of the Columbia River Treaty by the Entities (p.50 Tables 1M and 1), and will not be repeated here. This section gives a brief overview of the forecasts and focuses on the results of the verification of the Treaty project forecasts and any lessons learned.

CANADIAN PROJECTS

The Arrow local drainage is defined as the sum of the Arrow, Revelstoke, and Whatshan basins, while the Arrow total drainage is defined as the sum of the Arrow, Revelstoke, Whatshan, and Mica basins. Arrow local and total forecasts are aggregates of sub-basin forecasts.

Columbia River Treaty forecasts for Mica, Revelstoke, Arrow local and Duncan are based solely on statistical forecast model (i.e., principal component regression). For early-season (December) forecasts, total Feb-Jul forecast volumes are disaggregated into monthly volumes using the monthly runoff distribution from the 71-year mean. For consecutive forecast dates, total Feb-Jul volumes, or the residual thereof, are calculated by aggregating BC Hydro's monthly forecast volumes and disaggregated using the monthly runoff distribution from the 71-year mean. January forecasts are naïve (climatology, 71-year mean) forecasts. August forecasts are the difference between Apr-Aug forecasts and the Apr-Jul volume of the disaggregated Feb-Jul forecasts.

2011 Highlights

- 2011 water supply forecast year was characterized by La Niña conditions with cool, wet winter and spring with a very late spring freshet.
- The February-through-July observed inflow volumes to Columbia region projects were normal at Mica (99% of 71-year mean) and increased further south with both Arrow Local and Duncan at 109% of the 71-year mean.
- With the fall season being dry in the northern Columbia and wetter further south, early season predictions reflected the combined effects of microclimatic variations and the anticipated impact of La Niña on snow accumulation. By early January, forecasts for all basins dropped from those issued in December as December turned out to be abnormally dry.

- January saw above-normal precipitation resulting in a jump in the February forecast.

- Observed inflow volumes for Mica and Arrow fell within the ± 1 SE prediction bounds for most forecast dates and within ± 2 SE prediction bounds for all forecast dates. Although there were under-prediction errors for early season forecasts, forecasts issued in the mid to late season tracked the final observed volumes reasonably well.

- Duncan's forecasts were generally significantly under-forecast as the final observed inflow volumes fell at the + 2 SE prediction bound for most forecasts for the February – July volume and exceeds the +2 SE prediction bound for the April – August volume. This under-forecast can be partly explained by an unexpected late accumulation in the snowpack localized in the Duncan and Kootenay Lake watersheds at the end May. This increase was captured well in the forecast issued in July. It is not believed there is any issue with the forecast equations themselves, but rather the unusual conditions in 2011 are the cause of the under-forecast.

LIBBY

As mentioned earlier, the 2011 water year saw La Niña conditions with a cool, wet winter and spring and a very late spring freshet. The majority of the snowpack began to accumulate in earnest in February and increased until the runoff started. The observed April-August seasonal average snowpack was 140% of average. As seen in the table below, Libby Dam was significantly under-forecasted for the months of December through April (a negative value for number of standard errors indicates an under-forecast). During the May-June runoff season, issued forecasts were a standard error greater than the observed – reversing the previous five month trend of under-forecasting. The under-forecasting for this year was consistent throughout the Columbia Basin.

Month of Forecast	First-of-Month Apr-Aug Volume Forecast (MAF)	Model Standard Error	Number of Standard Errors Different Than Observed	End-of-Month Flood Control Target (FT)	End-of-Month Draft Requirement (KAF)
Dec	6262	905	-1.6	2411.0	2000.4
Jan	5610	747	-2.8	2424.5	1487.4
Feb	6656	515	-2.1	2392.7	2612.2
Mar	7111	460	-1.3	2364.0	3414.7
Apr	7191	500	-1.1	2359.2	3535.9
May	8165	463	1.0	2370.6*	3241.6
June	8099	398	1.0	2442.3**	736.9
Observed	7714				

* If refill had not started in May, the May end-of-month elevation target would have been empty (2287 feet, 4979.5 KAF draft).

** Based on Corps of Engineers flood risk management refill guidance

Schedule 1 CRTHC Action Items

Table 1 Outstanding Action Items 2011

Meeting Source	Description	Notes/Updates
OUTSTANDING ACTION ITEMS		
60.4.b	Establish a data working group to address ongoing data issues, document and improve data transfer protocols, and coordinate communication around changes and updates to data management systems.	NWS reps will be Harold Opitz and Kevin Berghoff Data group will be discussed in Feb 2011 CRTHC meeting
60.4.c	Disaster Recovery plans - Stephanie to determine what, if anything, BC Hydro will do about data recovery in the event of a major system interruption	BCH working on in 2011. BCH has established a remote/backup site in Calgary Pushing data to CROHMS to happen in future
64.2.d	Ensure that BPA and BCH data requirements addressed when CWMS v2.x is deployed	Deployment has been delayed and further delays are expected due to staffing and fiscal issues. CROHMS user survey is in progress to canvas for input.
66.6.e	Agree on a clear definition 'Treaty and Supporting Stations'	
67.3	Update POP Appendix 7 with 2010 level Modified Flow information once adopted	
68.5	Track NWRFC ESP generated forecast throughout the year and impact on treaty operations. Re-evaluate recommendation of 4th working day for forecast use for future years	
68.6	Create MOU between BPA and BCHydro for installation and maintenance of new snow pillows	

Table 2 Completed Action Items 2011

Meeting Source	Description	Notes/Updates
COMPLETED ACTION ITEMS		
57.2.c.2	Explore options to clarify HGH storage tables used for various uses and modeling.	Peter to follow up. USBR trying to consolidate and standardize to single table (with and without storage) for TSR
59.4.a	Stephanie to provide updated list of Environment Canada reference climate stations and core temperature and precip. Stations. Will cross-reference with Treaty station list. Will also include indication if stations are potentially vulnerable	Info will be folded into station update report
63.1.a	Investigate monitoring station coverage of upper Columbia by investigating station density vs. hydrologic response	This eventually became the snow pillow report
63.1.b	Pull together documentation on how suitable monitoring sites have historically been identified by BCH, Env Canada and BC MOE	64: BC MoE has no documentation on site selection criteria BCH has criteris and will use for impending site selection to convert existing sites
64.2.a	See if BCH getting what they need from Porthill/Bonners Ferry Climate Station	65: BCH is getting what they need
64.2.b	BCMOE is in transition and data nmanagement for SWE data uncertain	Concern to be noted in station update report
64.3.a	POP circulated to USACE/BPA/BCHydro staff about correct usage of Jan-July volumes for AER/TSR purposess unless deviation requested of CRTHC	Committee will raise concern to staff as to when and how and adjustment to/deviation from the TSR is done.
65.2.a	Review and provide comments to Corps Seattle District on new Libby volume forecast	
65.2.c	Change Table 8 in PoP to reflect errors in Dworshak calues and update Libby error terms from new forecast procedure	
65.4.a	Conduct briefing on CHPS/FEWS	
65.4.b.	Provide bulleted list of station siting criteria used by NRCS	
67.6	BCHydro to prepare presentation on BCH climate change studies	